(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 November 2002 (21.11.2002)

PCT

(10) International Publication Number
WO 02/093777 A2

(51) International Patent Classification[7]: H04B 7/00

(21) International Application Number: PCT/US02/14338

(22) International Filing Date: 7 May 2002 (07.05.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/855,268 15 May 2001 (15.05.2001) US

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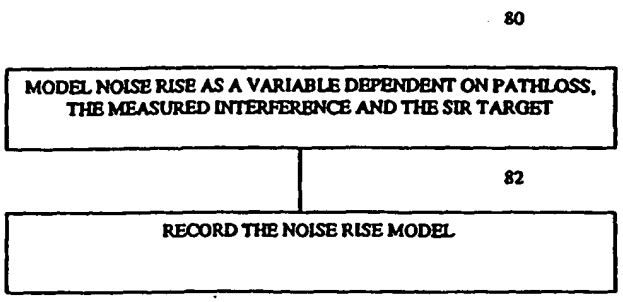
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: TRANSMISSION POWER LEVEL ESTIMATION



(57) Abstract: A model for noise rise of users in relation to an interference measure, a pathloss and a desired signal to interference ratio is provided. For a selected user, a pathloss, an interference measure and a desired signal to interference ratio is determined. A noise rise for the selected user is determined using the determined interference measure, pathloss, desired signal to interference ratio and the noise rise model. The selected user transmission power level is estimated using the determined noise rise.

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[0001] TRANSMISSION POWER LEVEL ESTIMATION

[0002] BACKGROUND

[0003] The invention generally relates to wireless communication systems. In particular, the invention relates to estimating transmission power levels in such systems.

[0004] Figure 1 depicts a physical layout of a wireless communication system. The system has a plurality of base stations 20. Each base station 20 communicates with user equipments (UEs) 22 in its operating area or cell 23. Communications transmitted from the base stations 20 to the UEs 22 are referred to as downlink communications and communications transmitted from the UEs 22 to the base stations 20 are referred to as uplink communications.

[0005] A network perspective of a wireless communication system is shown in Figure 2. Each node-B 24 within the system communicates with associated UEs 22 or users. Each node-B 24 has a single site controller (SC) 34 associated with either a single or multiple base stations 20. A group of node-Bs 24 is connected to a radio network controller (RNC) 28_1. To transfer communications between RNCs 28, an interface between the RNCs (IUR) 26 is utilized. Each RNC 28 is connected to a mobile switching center (MSC) 30 which in turn is connected to the core network 32.

[0006] In code division multiple access (CDMA) communication systems, multiple communications can be sent over the same spectrum simultaneously. The

multiple communications are distinguished by their codes. In time division duplex communication systems using CDMA (TDD/CDMA), the spectrum is time divided into repeating frames having time slots, such as fifteen time slots. In such systems, communications are sent in selected time slots using selected codes. A physical channel is defined as one code in one time slot. The use of a single code in a single time slot with a spreading factor of sixteen is referred to as a resource unit. Based on the type of service being provided to a user (UE 22) in the system, one or multiple physical channels may be assigned to support the users uplink and downlink communications.

[0007] Since multiple communications are simultaneously carried over the same frequency spectrum, one user's communications may interfere with another user's. To reduce such interference, transmission power control is used. In transmission power control, a transmission is sent at a power level so that only a desired reception quality is met, such as a signal to interference ratio (SIR), bit error rate (BER) or block error rate (BLER).

[0008] One transmission power control technique is open loop power control. In open loop power control, a transmitter's power level is determined using a pathloss estimate between the transmitter site and its desired receiver site. To estimate the pathloss, the receiver site transmits a signal and an indicator of the transmission power level of the signal. By subtracting the received power level from the transmitted power level of the signal, the pathloss is estimated. Using the pathloss estimate and a target signal to interference ratio (SIR), a transmission power level for the

transmitter is set. The value of the target SIR is based on the service type. Another type of power control is closed loop power control. Closed loop power control sends power commands from the receiver site to adjust the transmitter's power level.

[0009] When a new user or user service is added to a system, the new user will create interference to existing users communicating at the same time. To maintain their desired signal quality, the existing users typically increase their transmission power levels. However, some transmitters may be near their transmission power limits. As a result, adding the new user may create an unacceptable quality of service (QOS) for existing users.

[0010] To evaluate whether a new user should be added to the system, it is desirable to estimate the transmission power levels of the existing users, after admission of the new user. If all of the users, including existing and the new user, are all safely within acceptable transmission power levels, the new user is admitted. If a user's transmission power level is unacceptable, such as by being over its transmission power level capabilities, the new user is not admitted.

[0011] Accordingly, it is desirable to have better transmission power estimations.

[0012] SUMMARY

[0013] A model for noise rise of users in relation to an interference measure, a pathloss and a desired signal to interference ratio is provided. For a selected user, a pathloss, an interference measure and a desired signal to interference ratio is

determined. A noise rise for the selected user is determined using the determined interference measure, pathloss, desired signal to interference ratio and the noise rise model. The selected user transmission power level is estimated using the determined noise rise.

[0014] BRIEF DESCRIPTION OF THE DRAWING(S)

[0015] Figure 1 is an illustration of a physical layout of a wireless communication system.

[0016] Figure 2 is an illustration of a network layout of a wireless communication system.

[0017] Figure 3 is a simplified radio network controller for transmission power level estimation.

[0018] Figure 4 is a simplified node-B for transmission power level estimation.

[0019] Figure 5 is a simplified user equipment for transmission power level estimation.

[0020] Figure 6 is a flow chart for determining transmission power levels after admission for a new user or user service.

[0021] Figure 7 is a flowchart of determining transmission power levels using noise rise.

[0022] Figure 8 is a plot of a simulation of noise rise versus pathloss.

[0023] Figure 9 is a graph of a simulation of noise rise versus mean pathloss.

[0024] Figure 10 is a flowchart of compensating for missing pathloss information.

[0025] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0026] Figure 3 is a simplified RNC 28 for use in transmission power level estimation. The RNC 28 has a RRM device 36 and a measurement collection device 38. The measurement collection device 38 collects various measurements from other components of the network, such as the node-Bs 24 and the UEs 22. These measurements include transmission power levels (both uplink and downlink), pathloss information and other information. The RRM device 36 uses the measurements in determining efficient assignment of resources which is sent to the other components. The RRM device has a transmission power level estimation block 37 for use in determining the estimated transmission power levels.

[0027] Figure 4 is a simplified node-B 24 for use in transmission power level estimation. An antenna 40 receives radio frequency signals over a radio channel from the UEs 22. The received signals are passed through an isolator or switch 42 to a receiver 46 and a measurement device 48. A channel assignment device 44, which receives channel assignments from the RNC 28, identifies the physical channels and time slots to allow the receiver 46 to detect the transmitted data. The receiver 46 may be a multiuser detection device (MUD), a RAKE or a different type of receiver. The receiver 46 also recovers signaled information from the UE 22, such as measurement information, which is relayed to the RNC 28.

[0028] A measurement device 48 takes various measurements at the node-B 24, such as interference levels and reception power levels. These measurements are also relayed to the RNC 28. A transmitter 50 sends data and signaled information, such as channel assignments and a transmission power level of the node-B transmitter 24, to the UEs 22. The channel assignment device 44 determines a transmission power level for the node-B transmitter 50. The channel assignment device 44 controls the gain of an amplifier 52 to control the transmission power level. The transmitted signals pass through the isolator or switch 42 and are radiated by the antenna 40.

[0029] Figure 5 is a simplified UE 22 for use in RRM. An antenna 56 receives radio frequency signals over a radio channel from the node-B 24. The received signals are passed through an isolator or switch 58 to a receiver 66 and a measurement device 68. A channel assignment detection device 44 recovers the signaled information concerning the UE's channel assignments for both uplink and downlink. The receiver 66 may be a multiuser detection device (MUD), a RAKE or a different type of receiver.

[0030] A measurement device 68 takes various measurements at the UE 22, such as interference levels and reception power levels. These measurements are also relayed to the RNC 28 by being transmitted to the node-B 24. A transmitter 70 sends data and signaling information, such as measurements, pathloss information and a transmission power level of the UE transmitter 70, to the node-B 24. A transmit power controller (TPC) 60 determines a transmission power level for the node-B transmitter 60. The TPC 60 controls the gain of an amplifier 62 to control the

transmission power level. The transmitted signals pass through the isolator or switch 58 and are radiated by the antenna 56.

[0031] The following is an approach to estimate new transmit power levels for users in a system after admission of a new user or user service. The system's users use transmission power control, such as open loop power control, to reduce interference between users.

[0032] The approach is explained in conjunction with W-CDMA TDD/CDMA system, where uplink and downlink transmissions are assigned separate time slots. The approach is also applicable to CDMA systems where uplink and downlink transmissions are separated by frequency spectrum and other hybrid time division multiple access (TDMA)/CDMA and TDD/CDMA systems where uplink and downlink communications are assigned separate time slots or frequency spectrum, by including the out of band attenuation factor in the pathloss.

[0033] For the analysis, the system as shown in Figure 8 is divided into a region where for a particular time slot, M UEs 22 are served by N base stations 20. To simplify the analysis, it is assumed multi-user detection (MUD) receivers are used for both uplink and downlink reception, although the approach is extendable to other receivers, such as a RAKE receiver. Each base station 20 is assigned an index, such as j, where $j = 1, 2, \ldots, N$. Each base station j has a set $\Omega(j)$ UEs 22 connected to it. Each UE 22 is assigned an index, such as i, where $i = 1, 2, \ldots, M$. A new UE 22 or UE session, UE M + 1, is to be added to the region. UE M + 1 is proposed to be added to base station N.

[0034] For use in determining the transmit power levels for an uplink time slot, an i^{th} UE's initial uplink transmit power level prior to the addition of the new user is defined as $T^0(i)$, where 0 indicates the initial transmit power level. The new user's power is determined, such as by Equation 5.

$$T^0(M+1) = PL_{M+1,n} \cdot ISCP_{M+1} \cdot SIR_{UL}(M+1) \quad \text{Equation 5}$$

$PL_{M+1,n}$ is the pathloss between the M + 1 user and the base station. This value is typically determined at the base station n by subtracting a received power level of a signal from the UE 22 from its transmission power level. Alternately, the pathloss is estimated from other UEs 22 at a similar distance from the base station 20. $ISCP_{M+1}$ is the interference as measured using interference signal code power (ISCP) at the UE receiver. This value is either measured at the UE 22 or estimated by ISCP measurements by other similarly situated users. The ISCP can be replaced in the analysis with other types of interference measurements. $SIR_{UL}(M + 1)$ is the desired uplink signal to interference ratio at the base station for the M + 1 user.

[0035] The other users initial transmit powers are typically known or are estimated, $T^0(1), \ldots, T^0(M)$. An initial power vector is constructed (72), such as by Equation 6.

$$T^0 = \begin{bmatrix} T^0(1) \\ T^0(2) \\ \cdots \\ T^0(M) \\ T^0(M+1) \end{bmatrix} \qquad \text{Equation 6}$$

[0036] Each users power level is iteratively adjusted to generate an estimate of the transmission power levels that each user will reach at equilibrium after introduction of the new user M + 1.

[0037] The ISCP for each iteration as seen by user i is based on the transmission power of each user not in user i's cell divided by its estimated pathloss to user i's base station j. It is assumed that there is negligible cross-channel interference within each cell. This ISCP estimate is, preferably, used in an open loop type analysis to determine user i's power level for each iteration. One approach to calculated each k^{th} iteration's power level for user I (74), is per Equation 7.

$$\begin{aligned} T^K(i) &= PL_{i,j} \cdot ISCP^{K-1}(i) \cdot SIR_{UL}(i) \\ &= PL_{i,j} \cdot SIR_{UL}(i) \cdot \sum_{h=1, h \notin \Omega(j)}^{M+1} (T^{K-1}(h) / PL_{h,j}) \end{aligned} \qquad \text{Equation 7}$$

If the location of each user is know, the pathloss can be estimated using the user's location. Otherwise, the pathloss is estimated based on a typical expected pathloss between that user's cell and user i's base station adjusted by the pathloss to that user's base station. Alternately, user i's base station i may calculate that user's pathloss.

[0038] To facilitate implementation of the iteration analysis, each iteration can be viewed as a vector multiplication, such as per Equation 8.

$$T^K = A \cdot T^{K-1} \qquad \text{Equation 8}$$

A is an (M + 1) x (M + 1) matrix. In matrix A, an element A_{kl}, where k is the row and l is the column and ($1 \le k, l \le M + 1$) is given, such as per Equation 9.

$$A_{kl} = \begin{cases} 0, & \text{where } k \in \Omega(j), l \in \Omega(j) \\ (SIR_{UL}(k) \cdot PL_{k,j}) / PL_{l,j}, & \text{where } k \in \Omega(j), l \in \Omega(h), j \neq h \end{cases}$$

Equation 9

[0039] The iterations are continued until the transmission power levels converge (76), such as per Equation 10.

$$\frac{\left|T^{K+1}(i) - T^K(i)\right|}{T^K(i)} \le \delta, \text{ where } 1 \le i \le M + 1 \qquad \text{Equation 10}$$

δ is a convergence parameter, which is a small number, such as 1×10^{-4}. Alternately, a limit may be set to the number of iterations.

[0040] After convergence is met, each UE's estimated transmission power is checked against its capabilities. If all users have acceptable transmission power levels, the new user or service can be added (78). If some of the users exceed their capabilities or are unacceptably close to their capability limits, the new user or service is not admitted (78).

[0041] For the downlink time slots, the initial downlink transmission power levels are used to produce a downlink transmission power vector T^0 (72), such as per Equation 11.

$$T^0 = \begin{bmatrix} T^0(1) \\ T^0(2) \\ \cdots \\ T^0(M) \\ T^0(M+1) \end{bmatrix} \qquad \text{Equation 11}$$

The M + 1 user is proposed to be admitted to the N^{th} base station. The values for $T^0(i), \ldots T^0(M)$ are known or measured at their respective base stations 20. $T^0(M+1)$ is determined such as per Equation 12.

$$T^0(M+1) = PL_{M+1,n} \cdot ISCP_{M+1} \cdot SIR_{DL}(M+1) \qquad \text{Equation 12}$$

[0042] $PL_{M+1,n}$ is the measured pathloss between base station n and user M + 1 or the pathloss is estimated based on other users similarly situated. $ISCP_{M+1}$ is the measured ISCP or another interference measure at user M + 1, prior to admission. This value may also be estimated based on other users similarly situated. $SIR_{DL}(M+1)$ is the desired received downlink SIR at user M + 1.

[0043] Each user's downlink power level is iteratively estimated (74), after introduction of the new user M + 1. One approach to calculate each K^{th} iteration for an i^{th} user is per Equation 13.

$$\begin{aligned} T^K(i) &= PL_{i,j} \cdot ISCP^{K-1}(i) \cdot SIR_{DL}(i) \\ &= PL_{i,j} \cdot SIR_{DL}(i) \cdot \sum_{h \in \Omega(L),\, L=1,2,\ldots,N,\, L \neq j}^{M+1} (T^{K-1}(h) / PL_{L,j}) \end{aligned} \qquad \text{Equation 13}$$

L represents all other base stations 20 besides base station j of the i^{th} user. To facilitate implementation, determining each iteration, K, can be viewed as a vector multiplication such as per Equation 14.

$$T^K = B \cdot T^{K-1}$$ Equation 14

T^K is the determined transmission power levels. T^{K-1} is the determined power level of the preceding iteration. B is a (M + 1) x (M + 1) matrix. For an element at the r^{th} row and s^{th} column of B, such that $1 \leq r, s \leq M + 1$), B_{rs} is determined per Equation 15.

$$B_{rs} = \begin{cases} 0 & r \in \Omega(j), s \in \Omega(j) \\ (SIR_{DL}(r) \cdot PL_{r,j}) / PL_{r,i} & r \in \Omega(j), s \in \Omega(l), j \neq l \end{cases}$$ Equation 15

The iterations are continued until the transmission power levels converge (76), such as per Equation 16.

$$\frac{\left|T^{K+1}(i) - T^K(i)\right|}{T^K(i)} \leq \delta, \text{ where } 1 \leq i \leq M + 1$$ Equation 16

δ is a convergence parameter, which is a small number, such as 1×10^{-4}. The convergence parameter for the downlink may be the same or different than the uplink convergence parameter.

[0044] After convergence is met, estimated downlink transmission power is checked against the base station's transmission capabilities. If all transmitters 50 will be within acceptable transmission power levels, the new user can be admitted (78). If some of the transmitters 50 exceed their transmission power level limit or are unacceptably close to the limit, the new user is not admitted (78).

[0045] In some systems, all of the measurements required for the procedure of Figure 6 may not be available. One approach to determine the increase in transmission power as a result of a new assignment using noise rise is per Figure 7. The noise rise as a result of an assignment depends on the pathloss, the measured interference (I), such as measured using ISCP, and the SIR target for the transmitter of interest. As a result, empirically, the noise rise can be estimated.

[0046] The noise rise is modeled as a variable depending on the pathloss, the measured interference, and the SIR target. Using either simulation or field data, a noise rise model is developed (80). The data can be collected and updated during the system normal operation. The modeled noise rise may be stored as a table or a mathematical relationship (82), such as a curve or series of curves.

[0047] One equation for estimating noise rise is per Equation 17.

$$\text{Noise rise} = \Delta I\,(I, \text{pathloss}, SIR_{TARGET}) \qquad \text{Equation 17}$$

[0048] The noise rise is modeled as a change in the measure interference (I), ΔI. ΔI is a function of the measured interference, the pathloss and the target SIR.

Figures 8 and 9 illustrate obtaining a curve fitting the noise rise using simulation results for only the pathloss for simplicity. Data for the noise rise estimation can be obtained, including during the system normal operation, in the following way. Initially, a high fixed margin is used for resource allocation. Before every allocation, the interference level is recorded. After allocation, allowing the power control loops to adjust, the interference is measured again and compared to the before allocation value. The difference is tabulated as a function of the pathloss to the user, the before allocation interference and the required target SIR of the user. After a sufficient number of collections, a smoothing operation is used to create a final table or mathematical relationship, such as a formula.

[0049] Alternately, a generic table or mathematical relationship , such as derived from simulations, is used. The generic table or relationship is refined or updated during the normal system operations.

[0050] Figure 8 illustrates the simulated results of noise rise versus the pathloss. Figure 9 illustrates a curve representing the noise rise versus the mean pathloss. As a result, the noise rise for a transmitter can be estimated from that transmitter's pathloss.

[0051] The transmitter power level for a transmitter is determined using the estimated noise rise, such as per Equation 18.

$$\text{Transmit Power} = \text{Interference Measure} + \text{Pathloss} + SIR_{TARGET} + \text{Noise Rise} + \text{Measurement Error Margin} \quad \text{Equation 18}$$

The Measurement Error Margin is a design parameter used to compensate for measurement errors. The Measurement Error Margin is typically set at a conservatively high value to allow an adequate margin.

[0052] Under certain conditions, information concerning the transmitter's pathloss may not be available, as shown in Figure 10. Missing pathloss information may result in uplink time slots, where the UE transmission power level is unavailable for the pathloss calculation. To estimate the noise rise in such situations, a conservatively high stipulated value for the pathloss, $\overline{\text{pathloss}}$, is used (84). Using a high stipulated value, effectively overestimates the noise rise. Accordingly, the resulting determined transmission power levels are typically overstated. The noise rise is determined using Equation 19.

$$\text{Noise Rise} = \Delta I (I, \text{pathloss}, SIR_{TARGET}) \qquad \text{Equation 19}$$

The stipulated value for the $\overline{\text{pathloss}}$ may be a set value or a cell dependent parameter based on cell range and propagation conditions.

* * *

CLAIMS

What is claimed is:

1. A method for estimating a transmission power level of a selected user in a code division multiple access communication system, the method comprising:

providing a model for noise rise of users in relation to an interference measure, a pathloss and a desired signal to interference ratio;

determining a pathloss and a desired signal to interference ratio for the selected user;

determining a noise rise for the selected user using the determined interference measure, pathloss, desired signal to interference ratio and the noise rise model; and

estimating the selected user transmission power level using the determined noise rise.

2. The method of claim 1 wherein the estimated selected user transmission power level is estimated in part by adding the interference measurement, the pathloss and the desired SIR of the selected user to the determined noise rise.

3. The method of claim 2 wherein a measurement error margin is included in the estimated selected user transmission power level.

4. The method of claim 1 wherein the interference measure of the selected user is measured using ISCP.

5. The method of claim 1 further comprising generating the noise rise model and storing the noise rise model as a table.

6. The method of claim 1 further comprising generating the noise rise model and storing the noise rise model as a mathematical relationship.

7. The method of claim 1 wherein the determined pathloss for the selected user is measured.

8. The method of claim 1 wherein the determined pathloss for the selected user is a stipulated value which overestimates a pathloss.

9. The method of claim 1 wherein the system is a time division duplex communication system using CDMA and the selected user estimated transmission power level is for a single time slot.

10. A radio network controller (RNC) for estimating a transmission power level of a selected user in a code division multiple access communication system, the RNC comprising:

a radio resource management device for determining an interference measure, a pathloss and a desired signal to interference ratio (SIR) for the selected user, determining a noise rise for the selected user using the determined interference

measure, pathloss, desired SIR and a noise rise model, and estimating the selected user transmission power level using the determined noise rise; wherein the noise rise model uses variables including an interference measure, a pathloss and a desired SIR.

11. The RNC of claim 10 further comprising a measurement collection device for receiving the interference measure, the pathloss and the desired SIR for the selected user.

12. The RNC of claim 10 wherein the CDMA communication system is a time division duplex communication system using CDMA and the estimating transmission power levels is performed in a single time slot.

13. The RNC of claim 10 wherein the new user estimated transmission power level is estimated by adding a pathloss, an interference measurement and a target signal to interference ratio of the new user.

14. The RNC of claim 10 wherein the noise rise model is stored as a table.

15. The RNC of claim 10 wherein the noise rise model is stored as a mathematical relationship.

16. The RNC of claim 10 wherein the determined pathloss for the selected user is a stipulated value which overestimates a pathloss.

17. The RNC of claim 10 wherein the determined pathloss for the selected user is measured.

18. A radio network controller (RNC) for estimating a transmission power level of a selected user in a code division multiple access communication system, the RNC comprising:

means for determining an interference measure, a pathloss and a desired signal to interference ratio (SIR) for the selected user;

means for determining a noise rise for the selected user using the determined interference measure, pathloss, desired SIR and a noise rise model, the noise rise model uses variables including an interference measure, a pathloss and a desired SIR; and

means for estimating the selected user transmission power level using the determined noise rise.

19. The RNC of claim 18 wherein each last estimate is compared to a transmission power level capability associated with the user of that last estimate to determine whether to admit the new user.

20. The RNC of claim 18 wherein the system is a time division duplex communication system using CDMA and the selected user estimated transmission power level is for a single time slot.

21. A method for estimating a transmission power level of a selected user in a code division multiple access (CDMA) communication system, the method comprising:

determining an initial estimate of a transmit power level associated with the selected user;

providing a transmit power level of users of the system other than the selected user;

estimating subsequent estimates for the selected user and the other users using previous transmit power level estimates of the selected user and the other users; and

repeating the estimating subsequent estimates with a last repetition's estimated transmit power levels for the selected and other users being the estimated transmit power levels of the selected and other users.

22. The method of claim 21 wherein the initial estimate of the selected user is determined using an estimated pathloss between the selected user and a base station of the selected user, an interference estimate and a desired signal to interference ratio.

23. The method of claim 22 wherein the interference estimate is a measure of interference signal code power of the selected user.

24. The method of claim 22 wherein the interference estimate is a measure of interference signal code power of users situated similar to the selected user.

25. The method of claim 22wherein the estimated pathloss is a difference between a received power level and a transmit power level of a communication of the selected user.

26. The method of claim 22wherein the estimated pathloss is determined pathloss of users similarly situated to the selected user.

27. The method of claim 21 wherein the estimating subsequent estimates for each of the selected and other users is by using an estimated pathloss between users of cells other than a cell of that user and a base station of that user, an interference estimate and a desired signal to interference ratio.

28. The method of claim 27 wherein the interference estimate is determined by summing a transmit power level of users of cells other than a cell of that user divided by a pathloss between of the other cell user and that user's base station.

29. The method of claim 21 wherein the estimating transmit power levels is repeated until the estimated power levels converge.

30. A radio network controller (RNC) for estimating a transmission power level of a selected user in a code division multiple access (CDMA) communication system, the RNC comprising:

means for determining an initial estimate of a transmit power level associated with the selected user;

means for providing a transmit power level of users of the system other than the selected user;

means for estimating subsequent estimates for the selected user and the other users using previous transmit power level estimates of the selected user and the other users; and

means for repeating the estimating subsequent estimates with a last repetition's estimated transmit power levels for the selected and other users being the estimated transmit power levels of the selected and other users.

31. The RNC of claim 30 wherein the initial estimate of the selected user is determined using an estimated pathloss between the selected user and a base station of the selected user, an interference estimate and a desired signal to interference ratio.

32. The RNC of claim 31 wherein the interference estimate is a measure of interference signal code power of the selected user.

33. The RNC of claim 31 wherein the interference estimate is a measure of interference signal code power of users situated similar to the selected user.

34. The RNC of claim 31wherein the estimated pathloss is a difference between a received power level and a transmit power level of a communication of the selected user.

35. The RNC of claim 31wherein the estimated pathloss is determined pathloss of users similarly situated to the selected user.

36. The RNC of claim 30 wherein the estimating subsequent estimates for each of the selected and other users is by using an estimated pathloss between users of cells other than a cell of that user and a base station of that user, an interference estimate and a desired signal to interference ratio.

37. The RNC of claim 36 wherein the interference estimate is determined by summing a transmit power level of users of cells other than a cell of that user divided by a pathloss between of the other cell user and that user's base station.

38. The RNC of claim 37 wherein the estimating transmit power levels is repeated until the estimated power levels converge.

39. A radio network controller (RNC) for estimating a transmission power level of a selected user in a code division multiple access (CDMA) communication system, the RNC comprising:

a radio resource management device for determining an initial estimate of a transmit power level associated with the selected user; for providing a transmit power level of users of the system other than the selected user; for estimating subsequent estimates for the selected user and the other users using previous transmit power level estimates of the selected user and the other users; and for repeating the estimating subsequent estimates with a last repetition's estimated transmit power levels for the selected and other users being the estimated transmit power levels of the selected and other users.

40. The RNC of claim 39 wherein the initial estimate of the selected user is determined using an estimated pathloss between the selected user and a base station of the selected user, an interference estimate and a desired signal to interference ratio.

41. The RNC of claim 40 wherein the interference estimate is a measure of interference signal code power of the selected user.

42. The RNC of claim 40 wherein the interference estimate is a measure of interference signal code power of users situated similar to the selected user.

43. The RNC of claim 40wherein the estimated pathloss is a difference between a received power level and a transmit power level of a communication of the selected user.

44. The RNC of claim 40wherein the estimated pathloss is determined pathloss of users similarly situated to the selected user.

45. The RNC of claim 39 wherein the estimating subsequent estimates for each of the selected and other users is by using an estimated pathloss between users of cells other than a cell of that user and a base station of that user, an interference estimate and a desired signal to interference ratio.

46. The RNC of claim 45 wherein the interference estimate is determined by summing a transmit power level of users of cells other than a cell of that user divided by a pathloss between of the other cell user and that user's base station.

47. The RNC of claim 46 wherein the estimating transmit power levels is repeated until the estimated power levels converge.

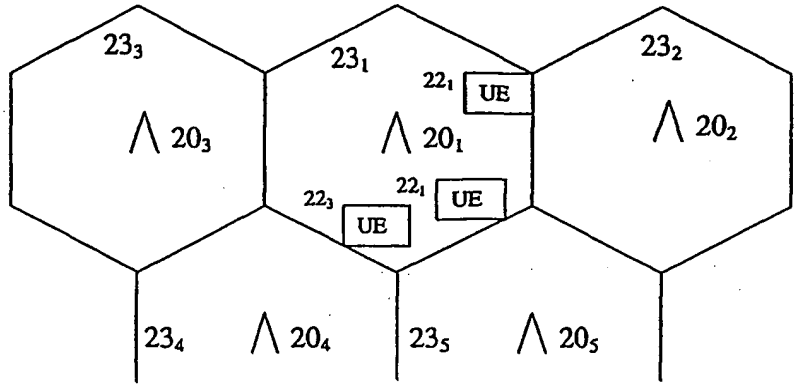


FIG. 1

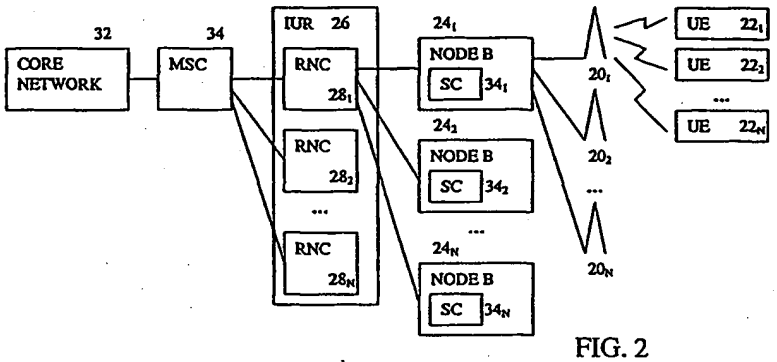

32
34
IUR 26
CORE NETWORK
MSC
RNC 28_1
RNC 28_2
RNC 28_N
24_1
NODE B
SC 34_1
24_2
NODE B
SC 34_2
24_N
NODE B
SC 34_N
20_1
20_2
20_N
UE 22_1
UE 22_2
UE 22_N

FIG. 2

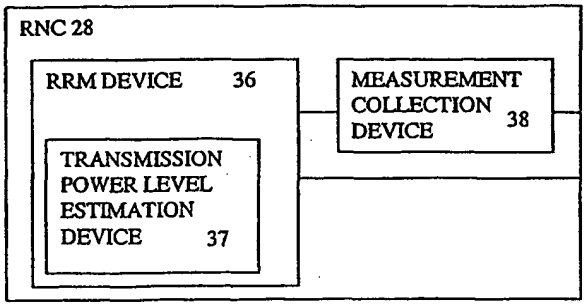


FIG. 3

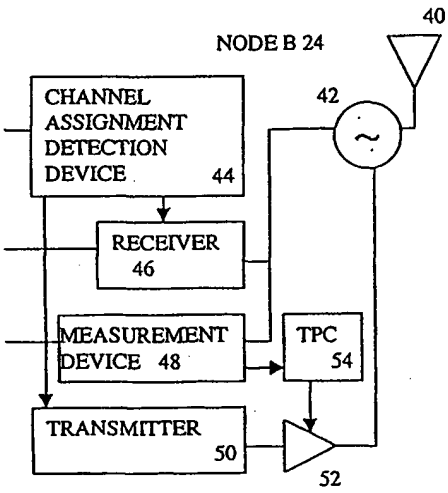


FIG. 4

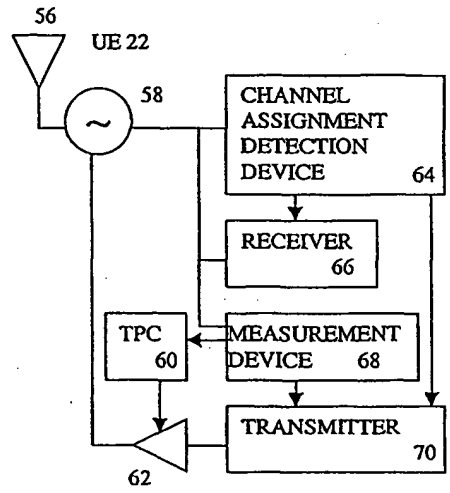


FIG. 5

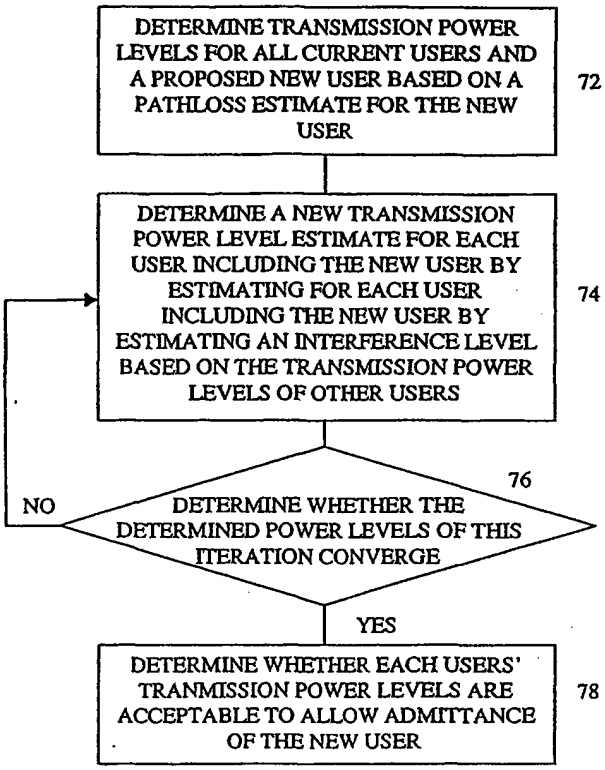

DETERMINE TRANSMISSION POWER LEVELS FOR ALL CURRENT USERS AND A PROPOSED NEW USER BASED ON A PATHLOSS ESTIMATE FOR THE NEW USER
72
DETERMINE A NEW TRANSMISSION POWER LEVEL ESTIMATE FOR EACH USER INCLUDING THE NEW USER BY ESTIMATING FOR EACH USER INCLUDING THE NEW USER BY ESTIMATING AN INTERFERENCE LEVEL BASED ON THE TRANSMISSION POWER LEVELS OF OTHER USERS
74
76
NO
DETERMINE WHETHER THE DETERMINED POWER LEVELS OF THIS ITERATION CONVERGE
YES
DETERMINE WHETHER EACH USERS' TRANMISSION POWER LEVELS ARE ACCEPTABLE TO ALLOW ADMITTANCE OF THE NEW USER
78

FIG. 6

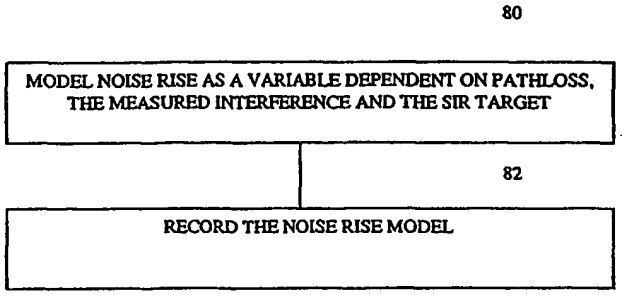

80
MODEL NOISE RISE AS A VARIABLE DEPENDENT ON PATHLOSS, THE MEASURED INTERFERENCE AND THE SIR TARGET
82
RECORD THE NOISE RISE MODEL

FIG. 7

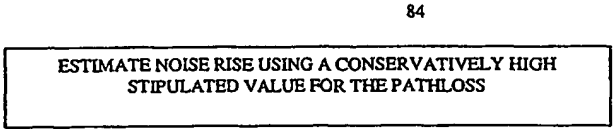

84
ESTIMATE NOISE RISE USING A CONSERVATIVELY HIGH STIPULATED VALUE FOR THE PATHLOSS

FIG. 10

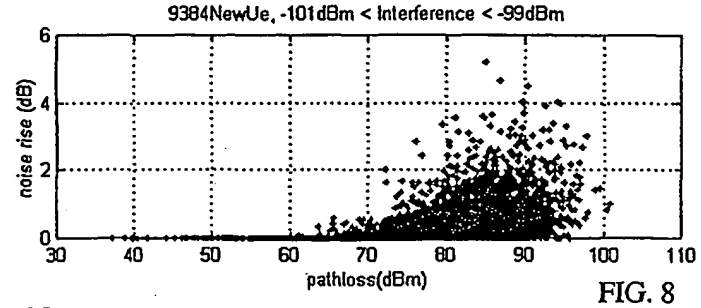

9384NewUe, -101dBm < Interference < -99dBm
noise rise (dB)
pathloss(dBm)
0
2
4
6
30
40
50
60
70
80
90
100
110

FIG. 8

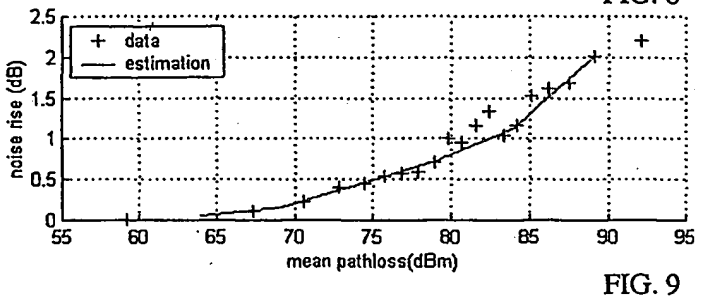

data
estimation
noise rise (dB)
mean pathloss(dBm)
0
0.5
1
1.5
2
2.5
55
60
65
70
75
80
85
90
95

FIG. 9

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 November 2002 (21.11.2002)

PCT

(10) International Publication Number
WO 02/093777 A3

(51) International Patent Classification[7]: H04B 7/005

(21) International Application Number: PCT/US02/14338

(22) International Filing Date: 7 May 2002 (07.05.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/855,268 15 May 2001 (15.05.2001) US

(71) Applicant: **INTERDIGITAL TECHNOLOGY CORPORATION** [US/US]; 300 Delaware Avenue, Suite 527, Wilmington, DE 19801 (US).

(72) Inventors: **ZEIRA, Eldad**; 239 West Neck Road, Huntington, NY 11743 (US). **ZHANG, Guodong**; 500 Peconic Street, Apt. 308 B, Ronkonkoma, NY 11779 (US).

(74) Agents: **VOLPE, Anthony, S.** et al.; Volpe and Koenig, P.C., One Penn Center, Suite 400, 1617 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW.

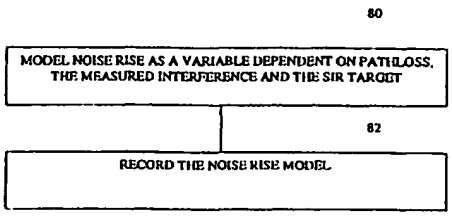
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
6 November 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: TRANSMISSION POWER LEVEL ESTIMATION



(57) Abstract: A model for noise rise of users in relation to an interference measure, a pathloss and a desired signal to interference ratio is provided. For a selected user, a pathloss, an interference measure and a desired signal to interference ratio is determined. A noise rise for the selected user is determined using the determined interference measure, pathloss, desired signal to interference ratio and the noise rise model. The selected user transmission power level is estimated using the determined noise rise.

WO 02/093777 A3

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/US 02/14338

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 063 788 A (CIT ALCATEL) 27 December 2000 (2000-12-27) abstract; claim 1 paragraph '0004! - paragraph '0007! paragraphs '0009!,'0011!,'0027! - paragraph '0036!	1-9,21
A	WO 97 07600 A (NOKIA MOBILE PHONES LTD ;SAARIO EIJA (FI)) 27 February 1997 (1997-02-27) abstract; claim 1 page 3, line 22 -page 5, line 25	1-21,30, 39
P,A	WO 01 62032 A (NOKIA NETWORKS OY ;HEISKA KARI (FI); HOLMA HARRI (FI); LAAKSO JANN) 23 August 2001 (2001-08-23) abstract page 1, line 29 -page 7, line 7	1-20

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 February 2003	06.03.03

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Katruff, M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/14338

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,A	EP 1 176 730 A (MOTOROLA INC) 30 January 2002 (2002-01-30) abstract	1-20
X	US 6 192 249 B1 (PADOVANI ROBERTO) 20 February 2001 (2001-02-20) abstract; figure 5 column 3, line 40 -column 4, line 9 column 6, line 1 - line 22	21-47
X	EP 0 936 753 A (NOKIA MOBILE PHONES LTD) 18 August 1999 (1999-08-18) abstract; figures 2-5 paragraphs '0002!,'0005!,'0009! paragraphs '0011!-'0013! paragraphs '0036!,'0074!; claims 1,2,17	21-47
A	US 5 987 333 A (SOLE GEOFFREY CHARLES) 16 November 1999 (1999-11-16) abstract; figure 1	21-47

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 02/14338

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-20

Independent claims 1, 10 and 18 relate to a method and a RNC controller for estimating a transmission power level in a CDMA communication system where the selected user transmission power is estimated using a determined noise rise which is based on a noise rise model of users in relation to an determined interference measure, a determined pathloss and a desired signal to interference ratio.

2. Claims: 21-47

Independent claims 21, 30 and 39 relate to a method and a RNC controller for estimating a transmission power level in a CDMA communication system where the selected user transmission power is estimated by using an initial estimation and repeating the estimating subsequent estimates.

INTERNATIONAL SEARCH REPORT

Information on patent family members

In tional Application No
PCT/US 02/14338

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1063788 A	27-12-2000	EP 1063788 A1	27-12-2000
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		DE 69618238 T2	08-08-2002
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